Sun worshipping: An introduction to cyclical events

Applied Trigonometry demonstration lesson (50-60 minutes) Note: This lesson was taught in April.

Goal: To model engaging students in characteristics of trigonometric functions by exploring cyclical phenomena, such as changes of average monthly high and low temperatures.

Lesson Objectives:
Students will relate their life's experiences with changes in average monthly high and low temperatures with cyclical events.
Students will estimate a graphical representation for cyclical events.
Students will connect graphical representation with different locations on earth (climate).
Students will begin to discover properties of cyclical graphs in the real world context.

NYS standards:

Lesson summary and background: Average temperatures for most places on earth vary in a cyclical pattern (close to a variation of the sine wave). But some places (like in the tropics) have very little variation and have nearly constant average high and low temperatures throughout the year. These data are available from websites such as www.weather.com. The process of temperatures is cyclical because the earth goes around the sun with a tilted axis. If the axis were not tilted we would not have these variations. Many people have misconceptions about what causes seasonal changes. Many think it is related to how far we are from the sun. In fact we are closer to the sun in the winter than in the summer! It is entirely related to the tilt of the earth's axis.
Students will investigate temperature data and graphs from different parts of the world. The "start point" for the data is the spring equinox. We can view this (and the fall equinox) as the equilibrium points. Temperatures tend to rise and fall away from and toward these points. The yearly graphs will allow us to establish many properties of trigonometric graphs without defining them yet. The real world context will form an anchor to which we can return as needed (*differentiation of instruction*).

Launch (students are sitting in pairs):

- Begin by asking students if the weather in January, February, and March has been **typical**. (Do you remember any really cold or warm months of March?) Accept ideas and steer toward **average** high and low temperatures for Harrison.
- In pairs ask them to draw a graph of the monthly average high and average low temperatures for Harrison, NY for one whole year beginning in April (now) and ending in April (next year). This graph should be an estimate based on their past experiences. [Prepare a graph sheet for each student, collect at end of class]
- After about 2 minutes show the data and the graph to all students and invite them to explain how their graphs are **similar or different** than the one presented.

- I will guide their thinking with the following questions [Present these questions on large poster size paper and post each one as it is posed. Keep these questions posted throughout the lesson]:
    - During which months is the average (hi/low) temperature about the same? What symmetries do you see in the graph? (*Symmetry around summer and winter solstice; spring and fall equinox as an equilibrium*);
    - Are the graphs of the average low and the average high temperatures the same shape? How can you tell from the graph and how from the data? Between which months does the average temperature change the most/the least? (*Comparing properties of graphs*)
    - If we would make a graph for five years in a row, what would it look like? (*Concept of period*)
    - When are the maximum and minimum average high and average low temperatures? Where is the middle average temperature? Are the average maximum and minimum equally far from the middle temperature? (*Amplitude*)

The Challenge:

- Explain that some natural events that seem to happen in patterns are of interest to mathematicians. They have found a way to mathematically describe these events.
- Tell them that in this lesson they will investigate graphs for other places on earth. Briefly discuss the idea of climate and how this relates to comparing the graphs of average high and average low temperatures for a given location. Use the Harrison graph and point out the large differences (vertical distance) between the graphs.
- Ask if they could think of places where the distance between the graphs is very small.
- Ask if they can think of places where the graph hardly has any "bumps" in them (is nearly flat).
- Tell them that they will be investigating graphs for other places on earth and that they should be ready to explain the similarities and differences by considering the climate of where the places are located.
- Explain parameters for behavior and what is expected they are ready for when returning to the whole group.

Explore (pairs of students will join to make a group of four):

- We will have groups of students explore average temperature graphs for a variety of places in the US, Northern and Southern hemispheres. We will present the data and associated graphs to them. We will divide the places among a number of groups of students. At least two groups will do the same graphs.
- They will be asked to answer similar questions as listed above in the summarize phase (see worksheets). In their group they will need to assign one spokes person.
- [Be prepared to assist student with describing locations and climates]

Summarize (students remain in groups):

- Each group presents its findings about its assigned graphs and related questions to the class (everyone will have these graphs in their packet). [Collect packets at end of class.]
- I will then drive the summarize phase toward the idea that many processes in nature and human made are cyclical like the temperature patterns.
- I will lift out the symmetries in the graph, its periodicy, and the idea of amplitude. I will bring a slinky and try to link to other real world phenomena.
- So then we can define Trigonometry as the study of cyclical patterns, with the understanding that not all repeating patterns are trigonometric in nature.